DIRECTIONS

FOR USING THE

IMPROVED SLIDING SCALE

OF

CHEMICAL EQUIVALENTS;

WITH A SHORT EXPLANATION

OF THE

DOCTRINE OF DEFINITE PROPORTIONS.

BY

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ADVERTISEMENT.

The great value of Wollaston's Scale of Chemical Equivalents is now universally acknowledged. It is one of those happy inventions, which, by a singular felicity of adaptation, condenses, in one view, a vast mass of information, and points out, with uncommon simplicity and precision, some of the most fundamental laws of Chemical Action. To the Practical Chemist it is quite invaluable—saving him a multiplicity of calculations, which must, otherwise, engross a large portion of his time; while, from the present state of Chemistry, it is no less useful to the Student, exhibiting, in the most striking manner, many of the most important relations of the science, and rendering him familiar, by bare inspection, with a wide range of Chemical Combinations.

In order to render it as extensively useful as possible, a great many additions have been made, while, at the same time, it has been very much simplified, by taking hydrogen as a standard of comparison, instead of oxygen, by which fractional numbers are avoided, formerly a source of very great inconvenience. An explanation has also been given of the Principles on which the Scale is constructed, and a copious Table of Chemical Equivalents, corrected according to the most recent analyses.

DIRECTIONS

FOR USING THE

IMPROVED SLIDING SCALE, &c.

Since the existence of chemistry as a science, no principle has been pointed out so broadly connected with the whole range of its investigations, as the doctrine of Definite Proportions. It embodies not only some of the most brilliant discoveries, but also many of the most useful practical applications of the science, and has enabled us to reduce to a systematic form, the accumulated mass of insulated facts, which, for a long time, so materially retarded the progress of discovery.

It is not therefore surprising, that it should have effected a very important change in the character of the science, and been so assiduously cultivated by every eminent chemist of the present day. Scarcely, indeed, have eighteen years elapsed since Mr. Dalton made known his Views of Chemical Combination, and though they were then blended with an in-

genious hypothesis concerning the atoms or ultimate particles of matter, they now form the basis of every scientific work on chemistry.

Dr. Wollaston soon appreciated the value of the laws pointed out by Mr. Dalton, and founded on them his Scale of Chemical Equivalents, one of the most valuable instruments which has been invented for assisting the analytical researches of the practical chemist, and facilitating the study of the most important laws and facts of chemical science. Dr. Thomson, in his late work, has observed, that to it we owe, in a great measure, the general adoption of the views of Mr. Dalton in Great Britain; and, indeed, the advantages to be derived from it, may be easily understood, since it shews, by bare inspection, the proportions in which the different substances represented on it combine with each other, whether simple or compound—the composition of all the most important compounds—the quantity of any salt which may be requisite to decompose a given quantity of any other—and the quantities of the new compounds arising from the decomposition.

Such an instrument, to the practical chemist, is quite invaluable, saving him a multiplicity of calculations, which otherwise must necessarily engross a large portion of his time. To the student, also, it is no less useful, exemplifying in a practical manner the fundamental laws of chemical action; while, at the same time, it renders him familiar with some of the most interesting and important facts which the science embraces.

In order to explain satisfactorily the nature of the scale, we shall, in the first place, give a brief sketch

of the chemical principles on which it is founded, then explain the manner of using it, and subjoin, for the sake of reference, an alphabetical table of the Chemical Equivalents of the different elements, and their most important compounds, exhibiting at the same time the atomical constitution of those whose composition is more complicated.

THE doctrine of Definite Proportions is the term which has generally been employed to express the laws pointed out by Mr. Dalton. It includes three general propositions, each of which will be separately considered. They were formerly described under the general title of the Atomic Theory, which arose from Mr. Dalton employing the term Atom in explaining his peculiar views with regard to the ultimate particles of matter; but we prefer the common term, especially as it involves no hypothesis.*

The first of these Propositions is, that *Bodies combine in certain fixed or definite proportions.* Thus, 36 parts of chlorine combine with 1 of hydrogen, and form 37 of muriatic acid; and 34 parts of zinc combine with 8 of oxygen; but these bodies do not combine in any other proportion.

There are many substances, on the other hand, which can combine in more than one determinate proportion; but no combination can be formed intermediate between these: the only compounds which copper and oxygen form with each other, are in the

* Those who wish to examine this subject more minutely, will find it discussed in my INTRODUCTION to the STUDY of CHEMISTRY. See Vol. I. p. 59, &c. and the note to page 156.

proportion of 64 of the former with 8 or 16 of the latter. Mercury also can combine with oxygen in the proportion of 200 of the former with 8 or 16 of the latter,—but no other combination of these elements has been observed.

These examples will serve to shew the nature of the first proposition, which has been established by the rigorous analyses of the first chemists of the day. Berthollet, however, maintained an opposite opinion in his elegant work on Chemical Statics, conceiving that bodies were disposed to unite with each other in any proportion between two certain points, that is, between the greatest and smallest quantities of any one substance which can combine with a given weight of any other, or, as it has been sometimes termed, between the maximum and minimum of combination. The inaccuracy of his views on this subject is now universally admitted, and Proust was among the first who brought forward a series of experiments disproving them.

We cannot pass over this proposition, however, without alluding to the well-known fact, that there are some cases where the combining substances can unite apparently in any proportion. This is very well exemplified in the case of water and alcohol, or water and sulphuric acid, and in the formation of metallic alloys. These have been regarded by some as completely overturning the doctrine of definite proportions, but they have not usually been viewed in this light; and the apparent combination of these different bodies, in unlimited proportions, are now generally considered as depending on the combination of a few definite compounds with each other.

The second proposition included in the Doctrine of Definite Proportions is, that *When any two bodies are combined with a given weight of a third substance, and then brought into combination with each other, they combine together in the same proportion in which they had previously united with this third substance.* For instance, one part of hydrogen combines with six of carbon, and eight of oxygen, in what proportion, then, will carbon and oxygen combine with each other? From the Doctrine of Definite Proportions, we infer that they will combine with each other in the same proportion in which they combined with hydrogen, or six parts of carbon will combine with eight parts of oxygen.

As this is an extremely important law, we subjoin the following table, which will place it perhaps in a still clearer point of view :—

Olefiant gas consists of	hydrogen	1 + 6	carbon.
Water - -	-	hydrogen	1 + 8 oxygen.
Carbonic oxide	-	carbon	6 + 8 oxygen.

Here we see plainly the remarkable fact, that carbon and oxygen unite together in the very same proportion in which they combine with hydrogen, and the same law extends throughout the whole series of chemical combinations.* Thus, 16 parts

* It may be necessary to observe, that this law applies only to the first combination which different bodies form with each other, when they unite together in more than one proportion. The reason of this will be easily understood when we have considered the next proposition.

by weight of sulphur combine with 1 of hydrogen; accordingly, we presume that the same quantity of sulphur will combine with 8 parts of oxygen; for, as we have already seen, 8 parts of the latter combine with 1 part of hydrogen. On the same principle, we infer that 36 parts of chlorine will combine with 8 of oxygen, both combining with the same quantity, viz. one part of hydrogen.

In this manner we determine the combining quantities of the different elements, and their compounds; and, if we take any one of them as a standard of comparison, and reckon it unity, it is obvious that we shall be able to see, at one glance, the proportions in which different bodies combine with it, and also with each other; for, according to the law we have just been illustrating, two bodies combine together in the same proportion in which they combine with a given weight of a third substance.

Dr. Wollaston introduced the term Chemical Equivalent to denote the numbers representing the proportions in which different bodies combine together; and, accordingly, if hydrogen be taken as a standard of comparison and reckoned unity, carbon will then be represented by 6, oxygen by 8, sulphur by 16, chlorine by 36, &c. and these numbers will accordingly be styled their Chemical Equivalents. The Chemical Equivalents of compounds, again, are represented by the numbers formed by the addition of the Chemical Equivalents of their elements; thus, that of water is represented by the number 9, for it is composed of one equivalent of oxygen = 8, and one of hydrogen = 1.

We may likewise observe that many authors use

the word *atom* to represent what others do by the terms Chemical Equivalent, Combining Quantity, Proportional, &c. It matters little indeed which of them be employed, provided we annex the same meaning to them all, and perhaps the term *atom* is, after all, more convenient than any of the former.

It is much to be regretted that different chemists should have assumed different standards in drawing up their tables of Chemical Equivalents; oxygen, for example, being, at the present moment, represented by the different numbers, 8, 1, 10, and 100. Dr. Wollaston assumed oxygen as a standard of comparison in his Scale of Chemical Equivalents, and represented it by the number 10; and almost all the scales which have been made have been constructed on this plan. A most important discovery, however, was made by Dr. Prout, who shewed, that if hydrogen was taken as a standard of comparison, and reckoned one, all the other elementary substances, and consequently their compounds, are represented by whole numbers; whereas, according to the other system, many of them are represented by fractional parts, which is extremely inconvenient. This singular fact will probably lead all chemists ultimately to adopt hydrogen as a standard of comparison; and, indeed, this has already been done in two of the most important philosophical journals of the day. As oxygen, however, is still represented by the number 10, in perhaps the greater number of works on chemistry, we shall, for the sake of reference, subjoin a table of atomic weights, according to both systems.

One of the most important corollaries derived from

the law which has just been stated, is, that *When two neutral salts mutually decompose each other, the resulting salts are also neutral.* This was noticed by Wenzel and Richter, long before Mr. Dalton advanced his atomic theory, and was explained satisfactorily, by attending to the proportions in which the acids combine with the salifiable bases to form neutral salts; but they did not extend their views farther than to these compounds. This subject, however, will be understood more easily if we take an example:—let us examine, for instance, the proportions in which sulphuric and muriatic acids combine with soda and lime, to form the sulphates and muriates of soda and lime:

40 parts of sulphuric acid neutralize	32 of soda.
40 - - - - - -	28 of lime.
37 parts of muriatic acid - -	32 of soda.
37 - - - - - -	28 of lime.

But if 72 parts of the sulphate of soda (=40+32) be mixed with 65 of the muriate of lime, (=37+28) a mutual decomposition ensues; the sulphuric acid (=40) leaves the soda and combines with the lime (=28), forming 68 parts of the sulphate of lime, while the muriatic acid (=37) combines with the soda (=32), forming 69 of the muriate of soda; and, on looking at the table, we observe that the different ingredients in the new formed salts have combined in the very proportions in which they neutralize each other.

There is another subject, also, not a little perplexing to the beginner, which, however, will appear

perfectly plain when he has examined the law which we have just explained. We allude to the action which takes place when a dry chloride is converted into a muriate, or a muriate into a dry chloride The explanation of these phenomena depends on a knowledge of the composition of water, and the compounds which undergo this change. Thus,

Water consists of	hydrogen	1 +	8	oxygen.
Muriatic acid -	hydrogen	1 +	36	chlorine.
Soda - - -	oxygen	8 +	24	sodium.
Chloride of sodium	chlorine	36 +	24	sodium.
Muriate of soda	muriatic A.	37 +	32	soda.

Now, if chloride of sodium be thrown into water, both these substances are decomposed; the hydrogen of the water (= 1) combines with the chlorine of the chloride (= 36), forming 37 of muriatic acid, while the sodium of the latter (= 24) unites with the oxygen of the former (=8), making 32 of soda; these two compounds, the muriatic acid and soda remaining in combination, and forming 69 of the muriate of soda. Again, when muriate of soda is converted into chloride of sodium, the following is the action which ensues:—The hydrogen of the muriatic acid (= 1) combines with the oxygen of the soda (= 8), forming nine parts of water, while the chlorine of the former, = 36, remains in combination with the sodium of the latter, = 24, forming 60 parts of the chloride of sodium. The same observations apply to all the chlorides which can be converted into muriates by the action of water.

We now come to the third proposition included

in the Doctrine of Definite Proportions, which is, *When one body combines with another in more than one definite proportion, the quantity of one of them, in the different combinations, will be found to be double, triple, or some simple multiple of the smallest proportion in which it combines with a given quantity of the other substance.* Thus, if five parts be the smallest quantity of A which can combine with 100 of B, 10 parts will be the next, and so on in succession, as in the following table:

The First combination consists of	A 5 + 100 B
Second - - -	A 10 + 100 B
Third - - -	A 15 + 100 B
Fourth - - -	A 20 + 100 B, &c.

It is no doubt true that there are several cases which seem to be exceptions to this law, but it is extremely probable that these are only apparent exceptions, and arise from our not being acquainted with the whole series of combinations which are formed by any individual element.

We shall now give one or two examples, which will shew, satisfactorily, the nature of this law.

Oxide of copper consists of	oxygen	8 +	64	copper.
Deutoxide		16 +	64	
Oxide of mercury . .	oxygen	8 +	200	mercury.
Deutoxide		16 +	200	
Hyposulphurous acid .	oxygen	8 +	16	sulphur.
Sulphurous		16 +	16	
Sulphuric		24 +	16	

Nitrous oxide .	oxygen 8 +	14 nitrogen.
Nitric oxide . . .	16 +	14
Hyponitrous acid . .	24 +	14
Nitrous acid	32 +	14
Nitric acid	40 +	14

Many more examples might have been given, but these are quite sufficient to shew the nature of this law. We must remark, however, that in drawing up a table of chemical equivalents, or in consulting it, for the purpose of ascertaining the proportions in which different bodies combine, or the composition of any compound, the student must take care to observe, whether the compound consists of one atom, or chemical equivalent of one substance united with one, two, or more atoms of another; this can only be attained by a reference to the scale, or a knowledge of the different compounds which different substances form with each other.

Before concluding this subject, we may remark, that an interesting discovery was made by Gay Lussac with regard to the combinations of gases. He found, that when they unite together, the bulk of the one always bears a simple ratio to the bulk of the other. Thus, 1 volume of oxygen combines with 2 of hydrogen and 2 of nitrogen; 1 volume of nitrogen again combines with 3 of hydrogen. It has also been ascertained, that when they unite in more than one proportion, the quantity of one of the combining substances is increased by some simple multiple of the smallest quantity of it which enters into the first combination. These general laws have received the appellation of the Theory of Volumes,

and it agrees strictly with the Doctrine of Definite Proportions, which will be seen clearly in the following table :

	Volumes.	Atoms.
Oxygen - - - -	1	8
Hydrogen - - -	2	1
Nitrogen - - -	2	14
Chlorine - - - -	2	36

Here the first column represents the proportion in which these different gases combine with each other by volume; while the second represents their chemical equivalents by weight : it is obvious, therefore, that the numbers in the last column indicate the comparative weight of the volumes of the different gases in the first column, and that one volume of oxygen will unite with two of hydrogen, two of nitrogen, and two of chlorine, in the first combination which it forms with these bodies, while hydrogen will combine with an equal volume of chlorine. These observations will serve to shew the necessary connection between the theory of volumes and the doctrine of Definite Proportions ; but, as the chemical equivalents of the different substances are all represented by weight on the scale, it will be unnecessary to dwell any longer on this subject.

After having explained, in as brief a manner as possible, the nature of the doctrine of definite proportions, the construction and manner of using the scale of chemical equivalents will be easily understood.

It consists of a table on which the names of the different elementary substances, and their most important compounds are written ; the numbers representing their combining quantities, or chemical equivalents, being placed opposite them on a sliding rule, so that at one view we can see the proportions in which these different substances combine with each other. These numbers are so arranged with regard to each other, (being laid down by means of a table of logarithms,) that we have always the same proportion between any two numbers which are at equal distances from each other. If we take a pair of compasses, for example, we shall find that there is the same space between 8 and 16, 16 and 32, 32 and 64, 64 and 128, &c. Or if we take the space between 10 and 20, we shall then find that there is the same distance between 20 and 40, 40 and 80, 80 and 160. In short, if we fix upon any number whatever on the scale, and take the distance of any number above it, we shall find that the number below, at the same distance, has the same proportion to the one first taken, as it has to the number above it. For instance, if we fix upon the number 12, and take any number above it, say 8, then at the same distance below 12 as 8 is above it, we shall find the number 18, but 18 : 12 : 8.

From these observations it will be easily perceived, that though the scale, as it is drawn up, represents the composition of only one fixed quantity of any of the compounds which are written on it, we have only to shift the moveable slider on which the numbers are written, and then we can ascertain the

composition of any quantity of any of the compounds, according to the length of the scale.

For example, on looking at the scale, we see that 20 parts of magnesia consists of 8 of oxygen and 12 of magnesium; but if we wish to know the composition of 100 parts of magnesia, we have merely to shift the slider until the number 100 stands opposite magnesium, and then we see, on looking to oxygen and magnesium, that it is composed of 40 of the former and 60 of the latter; oxygen and magnesium standing opposite their respective numbers, when 100 is opposite to magnesia.

Again, it is obvious, that as the scale is drawn up, it will only shew us the quantity of any salt which will decompose one given quantity of another; but, by moving the slider, we may ascertain the quantity that will be required to decompose any given quantity of the second salt. Thus, on looking at the scale, we see that sulphate of potash and muriate of barytes, are represented by the numbers 88 and 115 =203; and these salts will accordingly be completely decomposed when they are mixed together in that proportion; and, on looking to the new-formed salts, sulphate of barytes and muriate of potash, we find that there result 118 of the former and 85 of the latter, = 203, the quantity of materials originally operated on. If, however, we should wish to know the quantity of muriate of barytes requisite to decompose any quantity of the sulphate of potash, we have merely to move the slider till the number representing the quantity in question stand opposite the sulphate of potash, and then, on proceeding as

before, we shall find the quantity of muriate of barytes necessary for the decomposition, the quantities of the new-formed salts, and the proportion of their different constituents.

It is often necessary, in practical chemistry, to ascertain the quantity of dry sulphuric acid in a given quantity of diluted acid, or in any soluble sulphate. This is generally accomplished by adding a solution of the muriate of barytes to a given quantity of the liquid, as long as any precipitate takes place. All the sulphuric acid is thrown down in combination with the barytes, the precipitate is carefully washed, dried, and weighed; and, to ascertain the quantity of sulphuric acid in it, we have merely to shift the slider till the number representing the weight of the precipitate stand opposite the sulphate of barytes, the number opposite sulphuric acid, while the scale is in this position, representing the quantity of dry acid which it contains.

On looking along the scale, it will be observed, that some substances are represented two, three, or even more times, with the figures 2, 3, &c. prefixed. This is to shew that these bodies can enter into combination with others in more than one proportion. Thus, we have seen that oxygen combines with many of the metals in more than one proportion; 64 parts of copper, for example, combining with 8 or 16 of oxygen. Accordingly, opposite 72, we find the protoxide of copper, indicating that it consists of 64 parts of copper and 8 of oxygen; but lower down the scale, and opposite the number 80, we find the peroxide of copper. This contains exactly the same quantity of copper (64 parts,) as the

72 parts of the protoxide; it must, therefore, contain 16 parts of oxygen, and opposite 16 we find 2 oxygen. The same observations apply to water, and many other substances which enter into combination in more than one proportion.

With regard to muriatic acid, it has been considered as a compound of hydrogen and chlorine, according to the views of Gay Lussac and Thenard, and Sir H. Davy. The scale does equally well, whether we consider the compounds, called chlorides, as compounds of chlorine and a metallic base, or of dry muriatic acid with a metallic oxide. For example, when a solution of the nitrate of silver is added to a solution of the muriate of soda, a white precipitate is obtained; and, supposing that it weighs 146 grains, it will be considered as a metallic chloride, according to the new doctrine, consisting of 110 grains of silver + 36 of chlorine. Those, however, who maintain the old view of the constitution of muriatic acid, will regard it as a dry muriate, or a compound consisting of 28 parts of dry muriatic acid, and 118 of the oxide of silver.*

With regard to the atom of dry muriatic acid, according to the old doctrine, it is evident that it will be represented by the number 28; for, according to this view of the subject, the muriatic gas, the equivalent of which is 37, (and which is commonly regarded as

* It may be necessary to remind those who are beginning the study of chemistry, that muriatic gas is regarded as a compound of hydrogen and chlorine by those who regard chlorine as a simple substance; those again, who do not, regard it as a compound of water and real muriatic acid, which they maintain has never yet been obtained in an insulated state.

dry muriatic acid,) is considered as a compound of 1 atom of water = 9, with 1 atom of real muriatic acid, but 37 — 9 = 28. Accordingly, whenever we wish to ascertain the quantity of muriatic acid in a salt, according to the old view of its constitution, we must refer to the number 28, while those who are inclined to support Sir H. Davy's opinion, will considcr 37 as the equivalent of the dry acid. These observations will also serve to shew why the different metallic chlorides will still be represented by the same numbers when they are considered as dry muriates; for we have seen, that, according to the old view of the constitution of muriatic acid, its atom is represented by 28, which is nine less than the atom of the dry muriatic acid of Davy. But when a muriate is converted into a chloride, the same weight of water is given off; for the 8 parts of oxygen combined with the base, unite with the hydrogen = 1 in muriatic acid, and form 9 parts of water. The following table will be found useful in shewing the constitution of muriatic acid and the metallic chlorides according to both views:

According to the old opinion,

37 parts of muriatic acid gas consist of dry acid 28 + 9 water, and the real dry acid has never yet been obtained in an insulated state.

When this is combined with 32 parts of soda, 60 parts of rcal muriatc of soda are formed; the 9 parts of water that were combined with the acid remaining in combination, and forming altogether 69 parts, but these may be expelled by heat, and then we shall

obtain 60 parts of the dry muriate of soda, consisting of 28 acid + 32 soda.

According to the other view of this subject,

Muriatic acid gas is itself the pure dry acid containing no water nor oxygen, and

37 parts consist of chlorine, 36 + 1 hydrogen. These 37 parts combine with 32 of soda, forming 69 parts of real muriate of soda, and if this be exposed to heat, a decomposition will ensue, the 8 parts of oxygen contained in 32 of soda, combining with the hydrogen, = 1, in the muriatic acid, forming 9 parts of water which are liberated, while the chlorine = 36, combines with the sodium, = 24, and forms 60 parts of the chloride of sodium.*

From the manner in which the numbers are placed with regard to each other, it is evident, that if the scale had begun with the number 1, it must have been prolonged to a very great length, as the distance between 1 and 8 must have been the

* In order to render the constitution of these compounds as easily understood as possible, I have, in general, stated their composition on the scale, both according to the new and the old view of the constitution of muriatic acid ;—the name of Sir H. Davy being annexed to the compound in the former case, and that of Dr. Murray in the latter, as they are considered to be the great advocates of these different opinions.

It is easy to see, from what has already been stated, that the dry muriate of Sir H. Davy will always be represented by a number exceeding the dry muriate, according to the old view, by 9, for the latter is synonymous with a metallic chloride ; and, to convert it into a muriate, according to the general opinion of the day, we have merely to add an atom of water = 9, its hydrogen combining with the chlorine, and its oxygen with the metallic base of the chloride.

same as between 8 and 64, (See page 13.) To obviate this, and at the same time include those bodies whose chemical equivalents are less than 8, as hydrogen and carbon, we begin with oxygen, which is represented by 8, and 10 atoms of the hydrogen are taken and represented by the number 10, while 2 atoms of carbon are represented by the number 12. Accordingly, whenever we are examining the constitution of any compound containing hydrogen or carbon, we must divide the number representing the former by 10, and the latter by 2, in order to ascertain the true quantity of these substances. Thus 14 parts of the oxide of carbon consist of 8 parts of oxygen, $+ \frac{12}{2}$ parts of carbon $= 6$. Again, olefiant gas consists of 1 atom of carbon $= 6 +$ 1 atom of hydrogen, $= 1$. Its prime equivalent is therefore 7, but as the scale does not extend so low, 2 atoms of it are taken, $= 14$. We must accordingly always divide the number representing olefiant gas by 2, when comparing it with the other substances on the scale.

We have only to remark, that, in order to render the scale as extensively useful as possible, a great many additions have been made to it; while, at the same time, it has been very much simplified, by taking hydrogen as a standard of comparison instead of oxygen, which enables us to avoid fractional numbers. A full Table of Chemical Equivalents has been added, corrected according to the most recent analyses, and all the most important of these have been placed on the Sliding Scale.

If, however, it should be an object to any individual chemist, to have a particular class of compounds

arranged along the Scale, which, in the present instance, may have been omitted in order to retain some of more general utility, he has merely to refer to the Table of Chemical Equivalents, where he will find the number they are represented by according to the Hydrogen Scale, and write them on the margin opposite the proper number on the Sliding Scale, and then their combinations may be investigated in the usual manner.

CHEMICAL EQUIVALENTS.

Abbreviations.—A. Acid.—C. Carbon.—c. crystallised.—chl. chlorine.—H. Hydrogen.—N. Nitrogen.—O. Oxygen.—Sul. Sulphur.—S. Sulphate.

	H=1.	O=10.
Acetic Acid, O. 24		
+ 2 H. + 24 C.	50	62.5
c. 1 W.	59	73.75
Aluminum	10	12.5
Alumina	18	22.5
Ammonia	17	21.25
Antimony	44	55
chloride	80	100
iodide	168	210
protoxide	52	65
deutoxide	56	70
peroxide	60	75
sulphuret	60	75
Arsenic	38	47.5
sulphuret	54	67.5
sesquisulphuret,		
Sulphur 24	62	77.5
Arsenious A.	54	67.5
Arsenic A.	62	77.5
Barium	70	87.5
chloride	106	132.5
iodide	194	242.5
oxide (barytes)	78	97.5
peroxide	86	107.5
phosphuret	82	102.5
sulphuret	86	107.5
Benzoic A. O. 24 + 6		
H. + 90 C.	120	150
Bismuth	72	90
chloride	108	135
iodide	196	245
oxide	80	100
phosphuret	84	105
sulphuret	88	110
Boron	8	10
Boracic A.	24	30
c. 2 W.	42	52.5

	H=1.	O=10
Cadmium	56	70
chloride	92	115
iodide	180	225
oxide	64	80
phosphuret	68	85
sulphuret	72	90
Carbon	6	7.5
Bisulphuret	38	47.5
chloride	42	52.5
perchloride chl. 108		
+ 12 C.	120	150
subchloride chl. 36		
+ 12 C.	48	60
hydrochloride chl. 36		
+ 6 C. + 1 H.	43	53.75
phosphuret	18	22.5
hydruret (olef. gas)		
C. 6 + 1 H.	7	8.75
bihydruret (carb.		
H.) C. 6 + 2 H.	8	10
Carbonic oxide	14	17.5
acid	22	27.5
Cerium	50	62.5
oxide	58	72.5
peroxide, O. 12 + 50 c.	62	77.5
Chlorine	36	45
oxide	44	55
peroxide, O. 32 +		
36 chl.	68	85
Chloric A. O. 40 +		
36 chl.	76	95
Perchloric A. O. 56		
+ 36 chl.	92	115
Chloriodic A. chl. 72		
+ 124 iodine	196	245
Chlorocarbonic A.		
chl. 36 + 14 carb. ox.	50	62.5

	H=1.	O=10.
Chlorocyanic A. chl. 36		
+ 26 cyanogen .	62	77.5
CHROMIUM . .	28	35
oxide . .	36	45
deutoxide . .	44	55
Chromic A. . .	52	65
Citric A. O. 32 + 2 H.		
+ 24 C. . .	58	72.5
c. 2 W. .	76	95
COBALT . .	26	32.5
chloride . .	62	77.5
iodide . .	150	187.5
oxide . .	34	42.5
peroxide . .	38	47.5
phosphuret .	38	47.5
sulphuret . .	42	52.5
COLUMBIUM .	144	180
Columbic A. . .	152	190
COPPER (32. Thomson)	64	80
chloride . .	100	125
perchloride .	136	170
iodide . .	188	235
oxide . .	72	90
peroxide . .	80	100
phosphuret . .	76	95
sulphuret . .	80	100
bisulphuret . .	96	120
Corrosive Sublimate,		
chl. 72 + 200 merc.	272	340
Cyanogen, nitrogen 14		
+ 12 . .	26	32.5
FLUORINE . .	2 ?	2.5 ?
Fluoboric A. Boracic		
A. 24+10 Fluoric A.	34	42.5
Fluoric A. . .	10	12.5
Fluosilicic A. Fluoric		
A. 10 + 16 Silica .	26	32.5
Formic A. O. 24 + 1		
H. + 12 C. .	37	46.25
Gallic A. O. 24 + 2		
H. + 36 C. .	62	77.5
GLUCINUM . .	18	22.5
Glucina . .	26	32.5
GOLD . . .	200	250
chloride . .	236	295
bichloride . .	272	340
iodide . .	324	405
oxide . .	208	260
peroxide . .	224	280

	H=1.	O=10.
sulphuret, Sul. 48	248	310
HYDROGEN .	1	1.25
arsenureted .	39	48.75
carburet (olef. gas)	7	8.75
carbureted .	8	10
seleniureted .	41	51.25
sulphureted .	17	21.25
bisulphureted .	33	41.25
Hydruret of phospho-		
rus . .	13	16.25
Bihydruret of phospho-		
rus . .	14	17.5
Hydriodic A. .	125	156.25
Hydrocyanic A. .	27	33.75
Hyponitrous .	38	47.5
Hyposulphurous .	24	30
Hyposulphuric Sic. A. 40		
+ 32 Sous. A. .	72	90
IODINE . .	124	155
Iodic A. . .	164	205
IRIDIUM . .	30	37.5
chloride . .	66	82.5
oxide . .	38	47.5
peroxide . .	46	57.5
IRON . .	28	35
chloride . .	64	80
perchloride .	100	125
iodide . .	152	190
oxide . .	36	45
peroxide . .	40	50
sulphuret . .	44	55
persulphuret .	60	75
LEAD . .	104	130
chloride . .	140	175
oxide - -	112	140
deutoxide -	116	145
peroxide - -	120	150
phosphuret -	116	145
sulphuret -	120	150
Lime (calcium 20) -	28	35
chloride - -	64	80
LITHIUM - -	10	12.5
chloride - -	46	57.5
iodide - -	134	167.5
oxide (lithia) -	18	22.5
sulphuret - -	26	32.5
MAGNESIUM -	12	15
chloride - -	48	60
oxide (magnesia) -	20	25

	H=1.	O=10.
sulphuret	28	35
Malic A. O. 32 + 10 H. + 18 C.	60	75
MANGANESE	28	35
chloride	64	80
oxide	36	45
deutoxide	40	50
tritoxide	44	55
phosphuret	40	50
sulphuret	44	55
Manganeseous A.	52	65
Manganesic A.	60	75
MERCURY	200	250
chloride	236	295
Bichloride	272	340
iodide	324	405
periodide	448	560
oxide	208	260
peroxide	216	270
sulphuret	216	270
persulphuret	232	290
MOLYBDENUM	48	60
oxide	56	70
Molybdous A.	64	80
Molybdic A.	72	90
Muriatic A.	37	46.25
NICKEL	26	32.5
chloride	62	77.5
iodide	150	187.5
oxide	34	42.5
peroxide	38	47.5
phosphuret	38	47.5
sulphuret	42	52.5
NITROGEN	14	17.5
chloride, chl. 144 + 14 nitrogen	158	197.5
bicarburet (cyanogen)	26	32.5
tritiodide, iodine 372 + 14 N.	386	482.5
oxide (nitrous)	22	27.5
deutoxide (nitric)	30	37.5
Nitrous A.	46	57.5
Nitric A. (dry)	54	67.5
liq. s. g. 1, 5, 2 W.	72	90
OXYGEN	8	10
Oxalic A. O. 24 + 12 C.	36	45
c. 4 W	72	90
PALLADIUM	56	70

	H=1.	O=10.
oxide	64	80
PHOSPHORUS	12	15
chloride	48	60
bichloride	84	105
carburet	18	22.5
sulphuret	28	35
Phosphorus A.	20	25
Phosphoric A.	28	35
PLATINA	96	120
chloride	132	165
bichloride	168	210
oxide	104	130
peroxide	112	140
sulphuret	112	140
persulphuret	128	160
POTASSIUM	40	50
chloride	76	95
iodide	164	205
oxide (potash)	48	60
peroxide, O. 24	64	80
phosphuret	52	65
sulphuret	56	70
RHODIUM	44	55
oxide	52	65
peroxide	60	75
Saclactic A. O. 64 + 4 H. + 36 C.	104	130
SELENIUM	40	50
oxide	48	60
Selenic A.	56	70
SILICUM	8	10
oxide (silica)	16	20
SILVER	110	137.5
chloride	146	182.5
iodide	234	292 5
oxide	118	147.5
suboxide, O. 8 + 165 silver	173	216.25
phosphuret	122	152.5
sulphuret	126	157.5
SODIUM	24	30
chloride	60	75
iodide	148	185
oxide (soda)	32	40
peroxide	36	45
phosphuret	36	45
sulphuret	40	50
STRONTIUM	44	55
chloride	80	100

	H = 1.	O = 10.
iodide - -	168	210
oxide (strontites) -	52	65
phosphuret -	56	70
sulphuret - -	60	75
Succinic A. O. 24 + 2 H. + 24 C. - -	50	62.5
Sulphur - -	16	20
chloride - -	52	65
iodide - -	140	175
phosphuret -	28	35
Sulphurous A. -	32	40
Sulphuric A. -	40	50
liq. s. g. 1.85, 1 W.	49	61.25
Sulphureted hydrogen	17	21.25
bisulphureted hydrogen - -	33	41.25
Tartaric A. O. 40 + 2 H. + 24 C. -	66	82.5
c. 1 W. -	75	93.75
Tellurium - -	32	40
chloride - -	68	85
oxide - -	40	50
Tin - - -	58	72.5
chloride - -	94	117.5
bichloride -	130	162.5
oxide - -	66	82.5
deutoxide - -	74	92.5
phosphuret -	70	87.5
sulphuret - -	74	92.5
bisulphuret -	90	112.5
Titanium - -	32	40
oxide - -	40	50
Titanic A. - -	48	60
Tungsten - -	126	157.5
oxide - -	142	177.5
Tungstic A. -	150	187.5
Uranium - -	208	260
oxide - -	216	270
peroxide - -	224	280
Uric A. O. 8 + 28 N. + 36 C. - -	72	90
c. 2 W. -	90	112.5
Water - -	9	11.25
Yttrium - -	34	42.5
oxide (yttria) -	42	52.5
Zinc - -	34	42.5
chloride - -	70	87.5
iodide - -	158	197.5
oxide - -	42	52.5

	H = 1.	O = 10.
phosphuret -	46	57.5
sulphuret -	50	62.5
Zirconium - -	40	50
oxide (zirconia) -	48	60

SALTS.

	H = 1.	O = 10.
Alumina (18) Sulphate . .	58	72.5
Alum. 3 S. alumina + 1 S. potash + 25 W.,	487	608.75
Ammonia, (17) acetate	67	83.75
c. 7 W. .	130	162.5
arseniate . .	79	98.75
bicarbonate, 2 W. .	79	98.75
borate . .	41	51.25
c. 2 W. .	59	73.75
carbonate . .	39	48.75
citrate . .	75	93.75
fluoborate . .	51	63.75
hydriodate .	142	177.5
iodate . .	181	226.25
molybdate . .	89	111.25
muriate . .	54	67.5
nitrate . .	71	88.75
oxalate . .	53	66.25
c. 2 W. .	71	88.75
phosphate . .	45	56.25
c. 2 W. .	63	78.75
sesquicarbonate, 1 W. + A. 33+17 am.	59	73.75
succinate, c. 2 W.	95	106.25
sulphate . .	57	71.25
c. 1 W. .	66	82.5
sulphite . .	49	61.25
tartrate . .	83	103.75
Antimony (ox. 52) hydro sulphuret .	69	86.25
tartarised (tartar emetic) 2 A. + 3, ox antimony + 1, potash + 2 W.	354	442 5
Barytes (78) acetate	128	160
c. 3 W. .	155	193.75
arseniate . .	140	175
arsenite . .	132	165
carbonate . .	100	125
chlorate . .	154	192.5
citrate .	136	170

	H=1.	O=10
iodate . .	242	302.5
muriate, c. 1 W.	124	155
nitrate . .	132	165
oxalate . .	114	142.5
phosphate . .	106	132·5
phosphite . .	98	122.5
succinate . .	128	160
sulphate . .	118	147.5
sulphite . .	110	137.5
tartrate . .	144	180
BISMUTH (ox. 80) acetate . .	130	162.5
arseniate, 2 W. .	160	200
carbonate . .	102	127.
citrate . .	138	172.5
nitrate c. 3 W.	161	201.25
oxalate . .	116	145
phosphate 3 W. .	135	168.75
sulphate . .	120	150
tartrate 5 W. .	191	238.75
CADMIUM (ox. 64) acetate, c. 2 W. .	132	165
carbonate . .	86	107.5
nitrate c. 4 W. .	154	192.5
phosphate 1 W. .	101	126.25
sulphate, c. 4 W.	140	175
COBALT (ox. 34) acetate	84	105
arseniate, 4 W. .	132	165
carbonate - -	56	70
nitrate - -	88	110
oxalate - -	70	87.5
phosphate - -	62	77.5
sulphate - -	74	92.5
c. 7 W. -	137	171.25
COPPER (ox. 80) acetate	130	162.5
c. 6W. (com. verd.)	184	230
binacetate - - -	180	225
c. 3 W. (distilled verdigris) -	207	258.75
subacetate (1 acid + 2 B.) - -	210	262.5
carbonate - -	102	127.5
2 W. malachite	120	150
nitrate c. 7 W. -	197	246.25
phosphate - -	108	135
bisulphate, c. 10 W.	250	312.5
IRON (ox. 36) acetate 3 W. - -	113	141.25
carbonate - -	58	72.5

	H=1.	O=10.
sulphate - -	76	95
c. 7 W. -	139	73.75
LEAD (ox. 112) acetate	162	202.5
c. 3 W. -	189	236.25
subinacetate -	274	342.5
arseniate - -	174	217.5
benzoate - -	232	290
carbonate -	134	167.5
chlorate - -	188	235
chromate - -	164	205
sub-chromate -	276	345
citrate - -	170	212.5
nitrate - -	166	207.5
oxalate - -	148	185
phosphate - -	140	175
sulphate - -	152	190
tartrate - -	178	222.5
LIME (28) acetate -	78	97.5
arseniate - -	90	112.5
benzoate - -	148	185
carbonate - -	50	62.5
chlorate - -	104	130
chloride - -	64	80
chromate - -	80	100
citrate - -	86	107.5
fluate - -	38	47.5
muriate, 5 W. -	110	137.5
nitrate - -	82	102.5
oxalate - -	64	80
phosphate - -	56	70
succinate - -	78	97.5
sulphate - -	68	85
c. 2 W. -	86	107.5
tartrate -	94	117.5
LITHIA (18) carbonate	40	50
nitrate - -	72	90
phosphate -	46	57.5
sulphate - -	58	72.5
MAGNESIA (20) ammoniaco-phosphate -	93	116.25
carbonate - -	42	52.5
nitrate - -	74	92.5
muriate . .	57	71.25
phosphate . .	48	60
sulphate . .	60	75
c. 1 W. .	123	153.75
MANGANESE (ox. 36) acetate . .	86	107.5
benzoate . .	156	195

	H=1.	O=10.
carbonate	58	72.5
oxalate	72	90
phosphate	64	80
sulphate	76	95
c. 5 W.	121	151.25
MERCURY (ox. 208) nitrate	262	327.5
pernitrate (perox.)	270	337.5
sulphate (ox.)	248	310
persulphate (perox.)	256	320
bipersulphate	296	370
NICKEL (ox. 34) acetate	84	105
arseniate	96	120
carbonate	56	70
nitrate	88	110
oxalate	70	87.5
phosphate	62	77.5
sulphate	74	92.5
c. 7 W.	137	171.25
POTASH (48) acetate	98	122.5
arseniate	110	137.5
binarseniate, c. 1 W.	181	226.25
benzoate	168	210
carbonate	70	87.5
bicarbonate c. 1 W.	101	126.25
chlorate	124	155
chromate	100	125
bichromate	152	190
citrate	106	132.5
iodate	212	265
molybdate	120	150
nitrate	102	127.5
oxalate	84	105
binoxalate	120	150
quadroxalate	192	240
phosphate	76	95
succinate	98	122.5
sulphate	88	110
bisulphate, c. 2 W.	146	182.5
tartrate	114	142.5
bitartrate, c. 1 W.	189	236.25
Silver (ox. 118) acetate	168	210
arseniate	180	225
arsenite	172	215
carbonate	140	175
chlorate	194	242.5
chromate	170	212.5
molybdate	190	237.5

	H=1.	O=10
nitrate	172	215
oxalate	154	192.5
phosphate	146	182.5
sulphate	158	197.5
SODA (32) acetate	82	102.5
c. 6 W.	136	170
arseniate	94	117.5
binarseniate, c. 5 W.	201	251.25
benzoate	152	190
carbonate	54	67.5
c. 10 W.	144	180
bicarbonate	76	95
sesquicarbonate, c. 2 W.	83	103.75
chlorate	108	135
chromate	84	105
citrate	90	112.5
molybdate	104	130
nitrate	86	107.5
oxalate	68	85
phosphate	60	75
c. 12 W.	168	210
succinate	82	102.5
sulphate	72	90
c. 10 W.	162	202.5
tartrate	98	122.5
potash	212	265
Strontites (52) acetate	102	127.5
carbonate	74	92.5
chlorate	128	160
chromate	104	130
citrate	110	137.5
muriate, c. 8 W.	161	201.25
nitrate	106	132.5
oxalate	88	110
binoxalate	124	155
phosphate	80	100
sulphate	92	115
tartrate	118	147.5
ZINC (ox. 42) acetate	92	115
carbonate	64	80
chlorate	118	147.5
nitrate	96	120
oxalate	78	97.5
phosphate	70	87.5
succinate	92	115
sulphate	82	102.5
c. 7 W.	145	181.25